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Preplanned Studies

Spatial Analysis of HIV/AIDS Cases Among Out-of-School Youth Aged 15–24 Years — China, 2010–2020

Shaorong Wang¹; Junjie Wang¹; Peng Xu¹; Wanting Lyu¹; Mengjie Han^{1,†}

Summary

What is already known about this topic?

There are 4,000 new HIV infections every day worldwide, and 31% of which are in adolescents aged 15–24 years old. However, previous study is not aware of the distribution of out-of-school youth among this age group.

What is added by this report?

The crude reporting rate of HIV/AIDS among out-of-school youth aged 15–24 years old increased from 5.25 per 100,000 persons in 2010 to 13.75 per 100,000 persons in 2020 with a weakly aggregated spatial distribution. Local hotspots spread from southwestern China to the central, eastern, and northeastern areas.

What are the implications for public health practice?

In the future, HIV/AIDS awareness among out-of-school youth and research on epidemic characteristics should be strengthened.

In 2020, there was a daily increase of 4,000 new human immunodeficiency virus (HIV) infections globally, and 31% of which would be among adolescents aged 15–24 years old (1), defined as the youth by the United Nations (UN) (2). More importantly, a proportion of the youth are sexually active. Due to the lack of school-based HIV education and prevention services, out-of-school youth become more vulnerable to HIV infection than students. This study described the crude reporting rate of out-of-school youth aged 15–24 and illustrated the spatial distribution characteristics using global spatial autocorrelation and hot spot analysis, which was based on case-reporting areas. The objective of this study was to understand the epidemiological situation and spatial distribution of out-of-school youth. The crude reporting rate of human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) among out-of-school youth increased from 5.25 per 100,000 persons in 2010 to 13.75 per 100,000 persons in 2020 with a weakly aggregated spatial distribution. In addition, local hotspots gradually

spread from southwestern China to the central, eastern, and northeastern areas. In-depth studies should continue to be conducted in the future to understand the prevalence characteristics among out-of-school youth, while strengthening HIV prevention interventions and services for out-of-school youth in hotspots.

The crude reporting rate of out-of-school youth HIV/AIDS cases in China (data include the mainland of China only) from 2010 to 2020 was calculated as the ratio of the number of reported cases among out-of-school youths to the total out-of-school youth population, where the total out-of-school youth population was derived as the total population of youth aged 15–24 years old minus the student population in this age group. The total population of youth aged 15–24 was derived from the number of the population of youth aged 15–24 in the sample and the sampling fraction, which were both obtained from the China Statistical Yearbook. The number of enrolled students was obtained from the website of the Ministry of Education of the People's Republic of China and represented the total number of regular senior secondary schools, regular specialized secondary schools, vocational high schools, undergraduates in regular higher educational institutions (HEIs), and those in master's degree programs. The number of reported cases of students by cities in the mainland of China by year was obtained from the HIV/AIDS Comprehensive Response Information Management System (CRIMS).

A total of 128,646 out-of-school youth HIV/AIDS cases aged 15–24 were reported from 2010 to 2020, covering all provincial-level administrative divisions (PLADs) in China. The number of reported HIV/AIDS cases among out-of-school youth in China showed an increasing trend from 8,579 in 2010 to 13,750 in 2015 and decreased to 10,398 in 2020. The proportion of HIV/AIDS cases among out-of-school youth aged 15–24 years declined from 91.53% of all cases in this age group in 2010 to 77.76% in 2020. The Chinese crude reporting rate of out-of-school youth HIV/AIDS cases presented a general upward trend from 5.25 per 100,000 persons in 2010 to 15.04

TABLE 1. Number of reported HIV/AIDS cases and crude reporting rate among out-of-school youth aged 15–24 years in China, 2010–2020.

Year	Out-of-school youth aged 15–24 years reported HIV/AIDS cases	Proportion of out-of-school youth HIV/AIDS cases aged 15–24 years to all cases among 15–24 years (%)	Total population of out-of-school youth aged 15–24 years	Crude reporting rate (per 100,000)
2010	8,579	91.53	163,390,413	5.25
2011	9,225	89.57	157,930,318	5.84
2012	10,043	87.87	147,002,113	6.83
2013	11,222	87.47	138,494,425	8.10
2014	12,841	83.43	125,941,350	10.20
2015	13,750	80.95	112,201,357	12.25
2016	13,657	81.73	104,446,501	13.08
2017	13,230	81.13	95,893,937	13.80
2018	13,333	81.11	88,623,320	15.04
2019	12,368	78.33	82,561,534	14.98
2020	10,398	77.76	75,603,657	13.75
Total	128,646	83.04	1,292,088,925	9.96

per 100,000 persons in 2018, then dropped to 13.75 per 100,000 persons in 2020 (Table 1).

The cumulative number of newly documented out-of-school youth HIV/AIDS cases nationwide from 2010 to 2020 was analyzed by global spatial autocorrelation. The results showed global Moran's Index (Moran's I)=0.029, Z =5.021, P <0.001, indicating that there was a weakly positive spatial autocorrelation of HIV/AIDS cases among out-of-school youth in China from 2010 to 2020. The annual global autocorrelation analysis shows that Moran's I decreased from 0.058 in 2010 to 0.018 in 2014 and slightly increased from 0.019 in 2015 to 0.027 in 2020; the Moran's I in 2020 was still lower than that in 2010, indicating an overall downward trend in spatial aggregation (Table 2).

The study results of local hotspots from 2010 to 2020 using Getis-Ord G_i^* showed that the number of local hotspots for out-of-school youth HIV/AIDS cases in China, varying between 11 and 15, did not change much from 2010 to 2020. Chongqing, Chengdu, Beijing, Shanghai, Guangzhou, Kunming, and Liangshan Yi Autonomous Prefecture were stable hotspots. From 2010 to 2012, local hotspots for out-of-school youth HIV/AIDS cases were mainly located in the southwest of China, including Chongqing, Chengdu, Liangshan Yi Autonomous Prefecture, Kunming, Honghe Hani Yi Autonomous Prefecture, and Dehong Dai Jingpo Autonomous Prefecture. Between 2013 and 2020, the hotspots area gradually shifted to the central, eastern, and the northeastern regions, and more new hotspot areas began to emerge, mainly in the cities of Hangzhou, Changsha, Wuhan,

TABLE 2. Global autocorrelation analysis of the number of out-of-school youth HIV/AIDS cases in China, 2010–2020.

Year	Moran's I	Z Score	P value
2010–2020	0.029	5.021	<0.001
2010	0.058	9.811	<0.001
2011	0.052	8.410	<0.001
2012	0.036	5.828	<0.001
2013	0.026	4.294	<0.001
2014	0.018	3.188	0.001
2015	0.019	3.273	0.001
2016	0.019	3.335	<0.001
2017	0.020	3.403	<0.001
2018	0.016	3.004	0.003
2019	0.021	3.577	<0.001
2020	0.027	4.503	<0.001

Note: If Moran's $I \neq 0$ and $Z \geq 1.96$ or $Z \leq -1.96$, the distribution of cases is indicated as spatially correlated. If Moran's I was close to 0 and Z values ranged between -1.96 and 1.96 , the cases were randomly distributed and there was no correlation.

Xi'an, Zhengzhou, Shenyang, and Harbin. However, there were no cold spot cities in the country from 2010 to 2020, indicating that there have been no low agglomerative areas in China in recent years.

DISCUSSION

Young students aged 15–24 years old are a key group for HIV prevention in China, but the results of this study showed that out-of-school youth still accounted for more than 3/4 of young people aged 15–24 years old living with HIV/AIDS. Thus, out-of-

school youth should be a high priority group for prevention and control strategies. The results of this study demonstrated that the number of out-of-school youth HIV/AIDS cases had decreased since 2015. The increasing number of out-of-school youth HIV/AIDS cases may be attributable to the expanded testing strategy implemented in China, an actual increase in the number of cases or some other factors. The subsequent decline may be related to factors such as the gradual improvement of HIV prevention strategies and services in China and an increased awareness of health protection among out-of-school youth. The proportion of infected out-of-school youths among all HIV-infected persons aged 15–24 years presented decline in general. However, the crude reporting rate of HIV/AIDS cases among out-of-school youth was rising approximately 2.5 times from 5.25 per 100,000 persons in 2010 to 13.75 per 100,000 persons in 2020. Non-significant decreases in crude reporting rates were likely attributable to insignificant decreases in the number of cases in the numerator as well as a decrease of out-of-school youths in the denominator. In addition to that, this may be related to the expansion of HIV testing and the introduction of HIV prevention services in China. Specific factors will need to be explored in future studies.

The spatial autocorrelation results showed that the general spatial clustering was low, and the spatial clustering of each year decreased despite fluctuations. This might be due to a combination of factors, for instance, the development of more accessible transportation and a more mobile out-of-school youth population, which may lead to narrowing of the gap between high and low clustering areas. This suggests that HIV testing and intervention of mobile populations should be strengthened in the future.

This study found few changes in the number of hotspot districts. However, the number of hotspot cities in the southwest area gradually dropped over time, and those in the central and eastern area grew annually. Hotspot cities in the northeastern region, including Shenyang and Harbin were found in this study. However, hotspots were generated by various factors, such as the level of local economic development (3), the improvement of the level of testing, an increase in testing (4), and the rise of the number of cases, which requires in-depth work and further investigations in the future.

A previous study has shown that the proportion of HIV/AIDS cases among young students aged 15–24 years to all HIV/AIDS cases among young people 15–24 years has increased and the proportion of relative out-of-school youth has decreased between

2008 and 2016 (5), which is roughly the same trend as the change demonstrated in this study. A study among all infected cases aged 15–24 years showed that the proportions of reported cases increased in eastern and central China and decreased in the southwest (6). This is the same trend as the hotspots shown in this study.

This study was subject to some limitations. First, data on HIV/AIDS cases analyzed in this study were derived from CRIMS, where the number of reported cases was correlated with local HIV testing strategies and prevention service capacity. These factors need to be considered when CRIMS is being used. Additionally, demographic information reported in CRIMS for HIV/AIDS cases were reported by the infected individuals themselves, such as occupation, and may be subject to some information bias.

The number of cases among out-of-school youth aged 15–24 years between 2010 and 2020 showed an increase and then a decrease, and the spatial clustering was low, with local hotspots gradually spreading from southwestern China to the central, eastern, and northeastern areas. Future studies focusing on out-of-school youth should seek a deeper understanding of the epidemiological characteristics and the transmission patterns of HIV among this population, as well as strengthening HIV prevention interventions and services for out-of-school youth in hotspots.

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Vital Surveillances

Prevention of Mother-To-Child Transmission of HIV — China, 2011–2020

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ABSTRACT

Introduction: Prevention of mother-to-child transmission (PMTCT) of human immunodeficiency virus (HIV) is a global health focus in most parts of the world. The World Health Organization (WHO) launched the dual Elimination of Mother-to-Child Transmission (EMTCT) of HIV and syphilis initiative and released global guidance on criteria and processes for validation of the EMTCT in 2014. The purpose of this report was to analyze the key validation indicators of EMTCT of HIV in China from 2011 to 2020 and to provide relevant basis information for the implementation of EMTCT action in China.

Methods: The report described the coverage of maternal HIV screening and antiretroviral therapy usage for HIV infected pregnant women and their infants in China using the data from the national information systems of PMTCT of HIV, syphilis, and HBV management from 2011 to 2020.

Results: The rates of maternal HIV testing during pregnancy (predelivery and at labor) and predelivery increased from 92.9% (8,730,161/9,398,781) and 53.7% (5,050,569/9,398,781) to 99.9% (11,964,026/11,982,321) and 97.5% (11,679,924/11,982,321), respectively. The MTCT rate reduced from 7.4% to 3.6% between 2011 and 2020.

Conclusions: The data from the surveillance systems revealed that there was a marked increase in the coverage of HIV screening of pregnant women and antiretrovirals drugs use for HIV infected pregnant women and their infants in China from 2011 to 2020.

Prevention of mother-to-child transmission (PMTCT) of human immunodeficiency virus (HIV) is a global health focus in most parts of the world, leading to concerns of HIV transmission to their children. The PMTCT program was first piloted in Shangcai County of China in 2001 with the support of United Nations Children's Fund (UNICEF) (1). Two years later, the program was expanded to eight cities/counties in five Chinese provincial-level

administrative divisions (PLADs) with significant HIV epidemics. The World Health Organization (WHO) launched the global initiative to achieve the elimination of mother-to-child transmission (EMTCT) of syphilis in 2007 and integrated interventions of maternal syphilis into the existing elimination of HIV in 2015 (2). The national program on PMTCT of HIV, syphilis, and hepatitis B (HBV) has been available freely in China since 2010 and achieved universal coverage beginning in 2015 (3). With the rapid development of techniques and policies, the WHO launched the dual EMTCT of HIV and syphilis initiative and released global guidance on the criteria and processes for validation of the EMTCT in 2014 (4). With Cuba being the first country to achieve the elimination criteria, 14 countries and territories have been validated by WHO for eliminating both HIV and syphilis at the end of 2019 (5).

The goal of EMTCT programs was to ensure that mother-to-child transmissions (MTCTs) of HIV, syphilis, and/or HBV were controlled and reduced to a low level such that it ceases to be a public health problem. Validation indicators and targets were used to monitor achievement of EMTCT over a defined period. As for EMTCT of HIV, the indicators included impact and process indicators, the former included the HIV MTCT rate, and the latter included HIV testing coverage and antiretroviral therapy (ART) coverage of HIV-positive pregnant women. The year 2021 marked not only the twentieth anniversary for the implementation of PMTCT of HIV by the Chinese government, but also the threshold of making a National EMTCT Action Plan. The purpose of this report was to analyze the key validation indicators of EMTCT of HIV in China from 2011 to 2020 and to provide relevant information for the implementation of EMTCT action in China.

METHODS

During 2011–2020, the National Health

Commission issued 3 versions of the “Protocol for Prevention of MTCT of HIV, syphilis, and hepatitis B,” which contained the government’s response strategy, intervention measures, and requirements regarding organization and management. As for HIV, in every protocol, standardized intervention services for PMTCT of HIV covered the following: HIV testing for pregnant women, free antiretroviral therapy or prophylaxis for pregnant women, antiretroviral prophylaxis for 6 or 12 weeks for children, HIV testing for children, and other interventions (6).

The report described the coverage of maternal HIV screening and antiretroviral (ARV) drugs use for HIV infected pregnant women and their infants in China using the 2011–2020 national information system of PMTCT of HIV, syphilis, and HBV management data. The national information system of PMTCT of HIV was established in 2007 by the National Center for Women and Children’s Health of China CDC. Since 2011, the system started to collect data on PMTCT of syphilis and HBV. Data on HIV screening of pregnant women and ARV drugs use for HIV infected pregnant women and their infants was collected through mandatory case-reporting and monthly work statements by health facilities, including general hospitals, maternal and children’s hospitals, and other health providers across China. SPSS software (version 23.0, IBM Corp, Armonk, NY, USA) was used for all analyses. The rates of screening and ART usage were presented as frequencies and proportions, and we also described the HIV MTCT rate.

RESULTS

During 2011–2020, the total recorded number of pregnant women receiving antenatal care was 139,751,391; among them, 137,555,431 pregnant women received HIV testing, the total testing rate was 98.4%, and HIV test predelivery rate was 82.8%. The rates of maternal HIV testing during pregnancy (predelivery and at labor) and predelivery increased from 92.9% (8,730,161/9,398,781) and 53.7% (5,050,569/9,398,781) to 99.9% (11,964,026/11,982,321) and 97.5% (11,679,924/11,982,321), respectively (Table 1).

The ARV drugs use rates of HIV infected pregnant women and the prophylaxis treatment rates of their newborn infants consistently increased during the study period. From 2011 to 2020, the treatment rate and the prophylaxis rate increase from 74.1% (2,525/3,407) and 85.2% (2,849/3,344) to 97.4% (4,623/4,745) and 99.2% (4,710/4,746), respectively. Along with increasing uptake of comprehensive interventions for infected mothers and their infants, the MTCT rate reduced from 7.4% to 3.6% between 2011 and 2020 (Figure 1).

CONCLUSIONS

A better understanding of the implementation and outcomes of the program on PMTCT of HIV is needed for future strategies to achieve the WHO goal of EMTCT of HIV (7). The data from the surveillance systems revealed that there was an increase in the

TABLE 1. Testing rates of HIV among pregnant women, China, 2011–2020.

Year	No. of pregnant women*	HIV test during pregnancy		HIV test predelivery†	
		Number	Percentage (%)	Number	Percentage (%)
2011	9,398,781	8,730,161	92.9	5,050,569	53.7
2012	12,077,532	11,641,270	96.4	7,675,833	63.6
2013	13,073,673	12,717,373	97.3	8,986,577	68.7
2014	13,796,766	13,548,485	98.2	10,538,355	76.4
2015	13,982,380	13,792,525	98.6	11,535,100	82.5
2016	18,325,763	18,179,870	99.2	16,058,981	87.6
2017	17,567,063	17,494,598	99.6	15,960,411	90.9
2018	15,132,557	15,091,448	99.7	14,243,662	94.1
2019	14,414,555	14,395,675	99.9	13,942,700	96.7
2020	11,982,321	11,964,026	99.9	11,679,924	97.5

* In 2011, the number of counties that PMTCT covered was 1,156; from 2015, the central finance covered all counties nationwide; and since 2017, with the decreasing of birth rate, the number of pregnant women decreased.

† Predelivery means before the time of labor start.

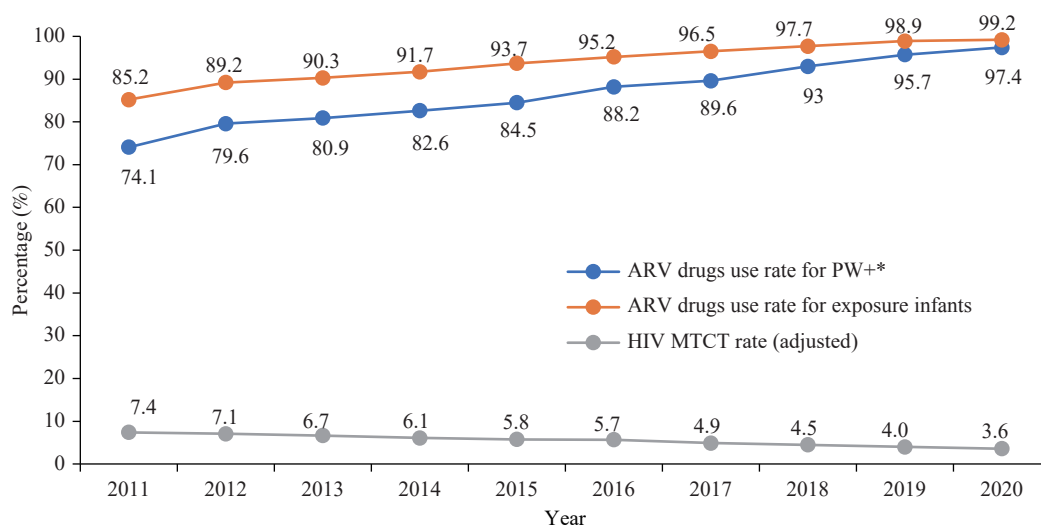


FIGURE 1. ARV drugs use rate of PW+ women and exposure infants and MTCT rate, China, 2011–2020. Abbreviations: ARV=antiretroviral; HIV=human immunodeficiency virus; MTCT=Mother-to-Child Transmission. *: PW+ means HIV positive pregnant women.

coverage of HIV screening of pregnant women and ARV drugs use for HIV infected pregnant women and their infants in China from 2011 to 2020. Before the antiretroviral therapy era, the MTCT rate of China was estimated to be 34.8% (8), this finding showed that the MTCT rate decreased from 7.4% to 3.6% between 2011 and 2020. Reviewing the latest 10 years, the national PMTCT program has covered almost every pregnant woman in China. The PMTCT services were integrated with antenatal care, perinatal care, and child healthcare in China. The work of the maternal and child health network guarantees the implementation of PMTCT services to a high level.

However, when compared with the criteria of validation of EMTCT of HIV, the main impact indicators have not met the standards; for instance, MTCT rate was <2% in non-breastfeeding populations. Furthermore, on the plan and road to push forward the EMTCT Action plan from 2021 to the national level, there are still some gaps in indicators compared with the validation criteria of EMTCT of HIV and the data quality needs to be improved. Hence, the current PMTCT intervention strategies need to be strengthened continuously under the background of the EMTCT. We will carry out relevant analysis and research work in the next step to uncover the reasons and influencing factors on these gaps with the aim of using the detailed indicators in the 31 PLADs of the mainland of China.

This study was subject to some limitations. First, we only analyzed data on HIV testing predelivery but did not do further research on the differences among the

three trimesters. Second, we only analyzed the total rate of ARV drugs use, but finding the proportion of different ARV drugs regimens is a better data point to reflect the achievements of PMTCT.

In conclusion, the expansion of the integrated PMTCT program both in content and coverage can significantly contribute towards achieving the goal of EMTCT, as well as addressing the ongoing burden of maternal health care. However, we still need to find and solve the problems, and to increase the pace of achieving EMTCT in China.

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Review

Research Progress in the Epidemiology of HIV/AIDS in China

Na He^{1, #}

ABSTRACT

After thirty-two years since the first domestic outbreak of human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS) among injection drug users (IDUs) and almost two decades of comprehensive response efforts by the Chinese government, HIV/AIDS remains a major public health problem. The increasing burden of HIV/AIDS and comorbidities, the emergence of new HIV subtypes and/or circulating recombinant forms and drug mutations, the changing transmission networks, and the urgency of immediate antiretroviral therapy initiation upon an HIV diagnosis are increasingly challenging and altogether likely to have significant impact on the HIV epidemic in China. Upon the call for the global AIDS response to end AIDS by 2030, China needs to develop an innovative and pragmatic roadmap to address these challenges. This review is intended to provide a succinct overview of what China has done in efforts to achieve the global goal of ending AIDS by 2030 and the recently proposed “95-95-95” target (95% combination prevention, 95% detection, 95% treatment, 95% viral suppression), and to summarize the most recent progresses in the epidemiological research of HIV/AIDS in China with the aim of providing insights on the next generation of HIV control and prevention approaches and to shed light on upgrading the national strategy to end AIDS in this country.

INTRODUCTION

As the global AIDS response shifts to end AIDS by 2030 upon a call from the new United Nations General Assembly Political Declaration, the Chinese effort to end AIDS is entering a new era. After thirty-two years since the first domestic outbreak of human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS) among injection drug users (IDUs) and almost two decades of well-funded and comprehensive response efforts by the Chinese government, HIV/AIDS remains a major public health

problem and a major cause of deaths in China. At the end of 2020, there were 1.053 million people living with HIV (PLWH) and 351,000 cumulative reported deaths in China (1). The proportion of heterosexual and homosexual transmission increased from 48.3% and 9.1% in 2009 to 74.2% and 23.3% in 2020, respectively, whereas the proportion of HIV transmission by IDU declined substantially from 25.2% in 2009 to <2.5% in 2020. The standardized mortality of HIV/AIDS in China rose dramatically from 0.33 per 100,000 people in 1990 to 2.50 per 100,000 people in 2016 (2). The changing epidemiological profile and increasing burden of morbidities and mortalities, together with the emergence of new HIV subtypes and/or circulating recombinant forms (CRFs) and drug mutations, the changing transmission networks, and the urgency of immediate antiretroviral therapy (ART) upon HIV diagnosis are emerging challenges and threats and altogether likely to have significant impact on the HIV epidemic in China. We herein briefly review and summarize the most recent progresses in the epidemiological research of HIV/AIDS in China with an aim to shed light on upgrading the national strategy to end AIDS in this country.

COMBINATION PREVENTION

HIV Risks and Prevention in MSM

Men who have sex with men (MSM) are the highest-risk group for HIV infection and present an increasing public health challenge in China. Dong et al. estimated the national prevalence of HIV among MSM through a systematic analysis of data extracted from 355 studies (571,328 individuals) covering 59 cities from 30 provincial-level administrative divisions (PLADs) of China (3). The overall national prevalence of HIV among MSM from 2001 to 2018 was estimated to be 5.7% [95% confidence interval (CI): 5.4%–6.1%], with the highest in those aged 50 years or older (19.3%). HIV was highly prevalent among those with illiteracy (16.8%), those in the southwest

(10.7%), and those seeking partners in bathhouses/saunas (13.4%). The HIV incidence among MSM was around 5.0 per 100 person-years (PY) (4), varying from 3.5 to >10.0 per 100 PY (5–9).

Some innovative interventions, including electronic or internet-based technologies, crowd-sourcing, preexposure prophylaxis (PrEP), and postexposure prophylaxis (PEP), have recently been evaluated among MSM (10–12). Yun et al. conducted a randomized controlled trial (RCT) showing that mobile phone interventions based on an HIV risk prediction tool is promising in promoting HIV testing and reducing high-risk behavior among MSM (13). The same group also demonstrated that an assisted partner notification (PN) strategy could increase uptake of HIV testing among sexual partners of recently diagnosed MSM (14). Tang et al. demonstrated that an innovative crowdsourcing approach was effective for developing and strengthening community-based HIV testing services for MSM (15). Integrating social media with the distribution of self-test kits also holds promise to increase HIV testing coverage and case identification among MSM (16).

The national pilot PrEP and PEP program was first launched in Tianjin Municipality in 2017, and expanded to 7 PLADs by 2019. However, less than one thousand were regularly taking PEP and even fewer taking PrEP. The awareness of and willingness to use PrEP and PEP among MSM was still extremely low (17–18). The probable barriers were the high price of PrEP (69.9%), the need to use condoms consistently (52.7%), concerns about side effects (39.8%), and concerns about effectiveness of prevention (22.6%) (18). Adequate PrEP promotions should be implemented, especially on the internet and dating apps.

HIV Risks and Prevention in Older Men

Older men have been increasingly and disproportionately affected by HIV over the past decade in China (19–20). According to China National Center for AIDS/STD Control and Prevention (NCAIDS), the proportion of newly reported HIV-positive cases made by males aged 60 years or older increased from 7.41% in 2010 to 18.21% in 2020 (1). The majority of them were infected through heterosexual contact (21). A recent meta-analysis pooling 30 studies of older men that were mostly at high-risk or MSM conducted during 2010–2018 in 13 PLADs found that the pooled HIV prevalence in

people aged over 50 years was 1.68% (95% CI: 1.00%–2.79%), higher (2.60%) in eastern China than in central and western China (0.16% and 2.13%) (22).

Limited studies have been designed to examine new interventions for HIV among older adults. Only few studies have been conducted to explore the efficacy of internet-or-network-based measures such as crowdsourcing or mobile apps in promotion of safer sex or HIV testing among MSM including those older than 50 years (15). Given the increasing spread of HIV among them, more HIV intervention studies that are psychosocially tailored for older adults are called for.

HIV Risks and Prevention in College Students

Cai et al. characterized the newly reported HIV/AIDS cases in young students in China between 2010 and 2019 (23). A total of 23,307 HIV/AIDS cases were reported in young students, with an overall male to female ratio of 33.9:1 and a mean age of (19.90±2.05) years. The new diagnosis rate showed decreasing trends [annual percentage change (APC) =−17.0] in the age group 23–24 years but increasing trend in the age group 15–17 years from 2015 to 2019 (23). The transmission route was mainly homosexual contact for males and heterosexual contact for females. Male cases were mainly identified by voluntary counseling and testing (VCT) clinics, whereas female cases were mainly found in hospitals (24). Liang et al. showed that there was a huge gap between female university students' willingness and practice of accepting VCT, as only 2.16% of the participants have ever had HIV tests (24).

Promoting safer sex and awareness of HIV status among college students is a major challenge for HIV control in China. Jiang et al. implemented an anonymous vending machine-based urine self-collection for HIV testing (USCT) program in colleges across China (25). From June 2016 to December 2019, 146 vending machines stocked with urine self-collection kits were distributed on 73 college campuses across 11 PLADs. Among the total of 5,178 kits sold, 3,109 (60%) samples were returned, 2,933 (94%) were eligible for testing, and of them 2.3% were tested HIV-positive, indicating that USCT is a powerful complement to current interventions that target at-risk students and promote HIV testing. Furthermore, given the low acceptance of PrEP and PEP by college students (26), studies are warranted to address this challenge.

HIV Risks and Prevention in FSWs

Zhang et al. recently summarized the national and regional levels of HIV prevalence among female sex workers (FSWs) based on reported rates in the literature from 2008 to 2018 (27). The overall national HIV prevalence was below 1%, showing a sporadic pattern in most PLADs. However, in the PLADs of Yunnan and Guangxi, the median-reported prevalence rates were close to or slightly above 1% (27). Using BED-CEIA, the HIV incidence among FSWs in Sichuan Province was estimated to be 0.22% (95% CI: 0.16%–0.28%) during 2011 to 2015 (28). Unfortunately, an accurate depiction of the epidemic in this population was obscured due to the lack of data on incidence. Notably, a rise in illicit use of synthetic drugs and changing sexual practices may represent newer risk factors for HIV transmission among FSWs, and a coordinated risk reduction framework remains urgently needed to address the dual epidemics of drug use and sexually transmitted infections (STIs) (29).

National prevention programs for HIV prevention in FSWs have widely promoted male condoms as a primary and practical measure. Limited studies have examined the feasibility and efficacy of innovative prevention tools or strategies, such as female condoms, PrEP, and PEP, to prevent HIV among FSWs or male clients (30). Given the vulnerability of FSWs to HIV infection, more research to gain comprehensive understanding of HIV incidence, risk trends, and innovative intervention strategies is needed.

HIV Risks and Prevention in Other Key Populations

ART adherence by the HIV-positive spouses could substantially reduce secondary HIV transmission within serodiscordant couples (31–32). The coverage of ART for serodiscordant couples has increased from 58.1% in 2011 to 96.6% in 2020, and correspondingly, the HIV seroconversion rate among HIV-negative spouses has decreased from 2.60% in 2011 to 0.34% in 2020 (1). There is no doubt that immediate ART coupled with condom use for newly diagnosed HIV-positive spouses continues to be the most efficient strategy for preventing the HIV secondary transmission between serodiscordant couples.

Methadone maintenance treatment (MMT) has significantly reduced new HIV infections among IDUs in China. At the end of 2020, there were 791 MMT clinics and 22 mobile vans providing on-site MMT

across 29 PLADs where 91,000 patients were served (1). The HIV seroconversion rate has declined by fourteen-fold from approximately 1% in 2006 to 0.07% in 2020. Needle exchange program for IDUs is also ongoing in 12 PLADs.

HIV DETECTION

Promoting HIV testing was an essential method to achieve the first 90% of the global “90-90-90” target (90% detection, 90% treatment, 90% viral suppression) by 2020, and the second 95% of the upgraded global “95-95-95-95” target (95% combination prevention, 95% detection, 95% treatment, 95% viral suppression). The overall person-times of HIV testing increased over four-fold from 55.6 million in 2009 to >240 million in 2020 (1). This goal was achieved by rigorous efforts in massive HIV screening and testing strategies in the past decade. For example, VCT has rapidly scaled up, from 6,077 VCT sites identifying 19,611 HIV positives out of 1,679,654 attendants in 2008 to 11,319 sites identifying 28,498 HIV positives out of 2,832,985 attendants in 2020 (1). On the other hand, HIV testing in medical institutes has been largely promoted through opt-out testing for clinical patients. In 2020, approximately 188 million person-times were tested and 79,475 were tested positive for HIV (1). However, delayed diagnosis of HIV infection remains a major concern for this strategy. Recent studies investigated the feasibility of and effective ways to promote home-based HIV self-testing (HIVST) in key populations especially MSM in China. Yan et al. conducted a large-scale longitudinal study among MSM who received the HIVST service based on a mobile app providing the “Mail-in rapid test reagent kit” in Harbin, Heilongjiang Province from July 2017 to June 2018 (33). Overall, 10% of the MSM adhered to HIVST every 100 days. Twenty HIV seroconversions were observed during one-year follow up (34). Those who adhered to HIV testing were more likely to improve condom use behaviors, but these results were not statistically significant. Zhang et al. found that providing free HIVST kits significantly increased testing frequency among Chinese MSM and further effectively enhanced partner HIV testing through distribution of kits within their sexual networks (33). From 2015 to 2020, the number of HIVST kits sold on internet increased from 1 million to over 5 million (35). Future research is needed to provide more insights into the development of internet-based and/or

social/sexual network-based interventions for HIVST among key populations.

MOLECULAR EPIDEMIOLOGY

HIV-1 Subtypes and Recombinant Forms

The distribution of HIV-1 subtypes and CRFs was highly diverse and complex in China. Yuan et al. conducted a systematic review and meta-analysis to provide a comprehensive prevalence estimate of different HIV-1 subtypes in sexual transmission by 2016 in China (36). A total of 130 eligible studies were identified, including 18,752 successfully genotyped samples. The pooled prevalence of CRF01_AE, subtype B, CRF07_BC, CRF08_BC, and subtype C were 44.54%, 18.31%, 16.45%, 2.55%, and 0.37%, respectively. HIV-1 subtype distribution varied significantly between regions. Recently, Wang et al. analyzed all Chinese *pol* region (2,253–3,252) sequences in the HIV Database to evaluate potential new CRFs in China (37). They found that CRF01_AE was the most prevalent genetic form in China, accounting for 39.69% of all national infections, followed by CRF07_BC (20.47%), subtype B (17.50%), CRF08_BC (6.60%), subtype C (6.28%), CRF55_01B (2.06%), and other CRFs (1.77%). The unique recombinant forms (URFs) were responsible for 5.31% of all infections nationwide. Among URFs, genomes comprising BC, 01BC, 01B, and 01C were dominant. Song et al. demonstrated that the HIV-1 phenotype and pathogenicity can be determined at the phylogenetic cluster level in the same subtype, highlighting the importance of monitoring the genetic evolution and phenotypic shift of HIV-1 to provide early warning of the appearance of more pathogenic strains (38).

HIV Drug Resistance

High prevalence of HIV drug resistance (HIVDR) would restrict therapy options, compromise the effect of current therapy regimens, and increase the risk of treatment failure. Zuo et al. systematically reviewed and assembled 218 datasets from 170 studies between January 2001 and March 2019, covering 21,451 ART-naive and 30,475 ART-treated PLWH in China (39). The pooled prevalence of transmitted drug resistance (TDR) was 3.0%, including 0.7%, 1.4%, and 0.5% resistance for nucleoside and nucleotide reverse transcriptase inhibitors (NRTIs), non-nucleoside reverse-transcriptase inhibitors (NNRTIs), and

protease inhibitor (PIs), respectively. TDR in the country overall has risen since 2012, and this rise was driven mainly by NNRTI resistance. Also, 1 NRTI-associated (M184V/I) and 3 NNRTI-associated (K103N/S, Y181C/I and G190A/S) mutations had high percentages in ART-naive and ART-treated individuals, and these mutations conferred high-level resistance to 3TC, EFV, and/or NVP (39).

HIVDR or mutations to PIs and other antiretroviral drugs (ARV) were also emerging. Yang et al. investigated the prevalence of integrase strand transfer inhibitors (INSTI)-associated resistance of HIV-1 strains in Henan Province during 2018–2020 (40). The prevalence of INSTI resistance was 1.2% overall, 0.63% for ART-naive patients, 2.05% for ART-treated patients with 14.63% for INSTI-treated and 0.76% for INSTI-naive patients. In a study of HIV-1 gp41 genetic diversity and enfuvirtide (ENF/T-20) drug resistance-associated mutations (DRMs) among enfuvirtide-naive patients in southern China, known DRMs were detected in 27.5% of ENF treatment-naive patients, which have been proved to elevate resistance to ENF (41). Undoubtedly, HIVDR or DRMs will continue to evolve in an increasing trend which warrants enhanced surveillance and monitoring.

HIV Molecular Transmission Networks

In recent years, molecular transmission networks based on evolutionary theory and sequence analysis have been widely used in research on HIV transmission dynamics and for precise interventions for high-risk populations. Ma et al. conducted a study of PLWH who were sexually transmitted in Liaoning Province from 2003 to 2019 (42). They found that the molecular transmission networks formed by CRF01_AE, CRF07_BC, and B did not have interconnections. A molecular epidemiological study of HIV-1 among newly diagnosed MSM in 2017 in Jiangsu Province found that 182 (23.7%) of 767 sequences were included in the HIV-1 transmission networks, forming 79 clusters with 4 clusters identified as fast-growing (43). Transmission among young MSM within networks was greater than the other age groups; thus, they could be essential in the control of the HIV epidemic in Jiangsu Province. Li et al. constructed genetic transmission networks of CRF08_BC based on its *pol* sequences, derived from the National HIV Molecular Epidemiology Survey (44). Of the 1,829 subjects, 639 (34.9%) were clustered in 151 transmission networks. The most crossover links were found between heterosexual

women and IDUs, with 30.9% heterosexual women linked to IDUs. These new findings underscored the importance of constructing molecular transmission networks and conducting long-term molecular monitoring, in addition to constructing behavioral networks and contact tracing (45) to further inform targeted measures for precise HIV prevention and control.

ANTIRETROVIRAL THERAPY AND VIRAL SUPPRESSION

Presently, the 4th edition of the *China's National Guidelines for Free ART* serves as the standard national reference, with continuous updates in regimens, enrollment criteria for ART, monitoring for CD4 counts, and HIV viral load and adverse effects of ARV. At the end of 2020, 978,138 (92.9%) out of the total of 1.053 million PLWH in China were receiving ART, 96.1% of those on ART were able to achieve viral suppression (1). To further address the challenges in maintenance of a sustainable national ART program and a continuum of HIV care, including implementation of the test-and-immediately-treat policy and provision of care for individualized health needs of the patients (46–47), China is examining various service models for treatment and care. For example, the previous CDC-led AIDS treatment program and mode of management had been transferred to the hospital-based model years ago, which had proved to be effective and successful (48). Most recently, as the body of PLWH continuously increases, a community-based model for patient management is being examined to ameliorate work overload suffered in the hospital-based model.

BURDEN OF HIV/AIDS MORBIDITY AND MORTALITY

With a secondary analysis of the Global Burden of Diseases, Injuries, and Risk Factors Study 2017 data, Liu et al. observed that the HIV prevalence in China increased from 1990 to 2009 with an annual percent change (APC) of 10.7, and then remained stable from 2009 to 2017 (APC: 0.7) (49). A significant increase in HIV incidence was also observed for 1990 to 2005 (APC: 13.0) and then a significant decrease was detected for 2005 to 2017 (APC: –6.5). However, the AIDS-related mortality has increased sharply for 1990 to 2004 (APC: 10.3) and for 2013 to 2017 (APC:

15.3), although it stabilized for 2004 to 2013 (APC: 1.3) (49).

Morbidity and mortality of non-AIDS-defining diseases (NADs) have become the increasing burden of PLWH with long-term ART (50–57). Wang et al. carried out an evaluation of the burden, risk factors, and prognosis of serious non-AIDS-defining events (NADEs) among ART-naïve AIDS patients admitted to a tertiary hospital between 2009 and 2018 in China (58). Among 1,309 patients, 143 (10.9%) had at least one serious NADEs, including 49 (3.8%) with cerebrovascular diseases, 37 (2.8%) with non-AIDS-defining cancers, 28 (2.1%) with chronic kidney diseases, 26 (2.0%) with cardiovascular diseases (CVD), and 18 (1.4%) with liver cirrhosis. Liu et al. also quantified the contribution of modifiable risk factors to NADs including CVD, end-stage liver disease (ESLD), advanced renal disease (ARD), and non-AIDS-defining cancers (NADCs) among 8,301 PLWHs starting ART at the Third People's Hospital of Shenzhen (China) from 2010 to 2017 (59). Incidence of CVD (362 per 100,000 PY) was the highest among outcomes, followed by that of ARD (270 per 100,000 PY), ESLD (213 per 100,000 PY), and NADC (152 per 100,000 PY). The contribution of traditional risk factors such as smoking, hypertension, and diabetes for these NADs far outweighed the HIV-related risk factors. An earlier cross-sectional study found that a third of PLWH had metabolic associated fatty liver disease, formerly named non-alcoholic fatty liver disease (60). Individual-level interventions and population-level policymaking is needed to prevent NADs in long-term management of HIV infection in China.

SYSTEMS EPIDEMIOLOGY OF HIV/AIDS

Despite viral suppression by ART, HIV infection is associated with ongoing activation of the immune system and persistent inflammation (61), which are key driving forces in the loss of CD4+ T cells, progression to AIDS, and development of non-HIV-related but aging-related chronic complications (61). An early loss of gut mucosal integrity, the following microbial translocation, and other co-infections are all factors contributing to the ongoing immune activation and sustained inflammation (62). Genetic factors also play important roles in development of various non-communicable chronic diseases (NCDs) in HIV

infection. Zhao et al. demonstrated that the Asian-specific mitochondrial DNA haplogroups G and N9 may confer higher risk for the development of multiple sclerosis (MS) in PLWH in China (63).

Very recently, Ding et al. conducted a case-control study using untargeted metabolomics to characterize the key metabolites and metabolic pathways associated with HIV infection and multiple NCDs, focusing on identifying the common metabolic pathways underlying them (64). They found that PLWH presented widespread alterations in cellular metabolism versus HIV-negative individuals, and glycerophospholipid metabolism emerged as the potential common metabolic pathway underlying NCDs in treated HIV infection; followed by d-glutamine and d-glutamate, and alanine, aspartate and glutamate metabolism. The same group also performed 16S rRNA gene sequencing and untargeted metabolomics on fecal samples of PLWH with or without neurocognitive impairment (NCI). The results show that the decreased abundance of butyrate-producing bacteria, the increased abundance of *Klebsiella*, and the associated metabolites were associated with NCI in PLWH (65).

Further systems epidemiological research combining epidemiological data with system biology is needed to confirm these findings and to identify new mechanisms of aging-related NCDs comorbid with HIV infection using longitudinal multi-omics in China.

HIV/AIDS DURING THE COVID-19 EPIDEMIC

The coronavirus disease 2019 (COVID-19) pandemic has posed a serious threat to prevention, treatment, and healthcare services for HIV. From January 1 to April 16, 2020, 35 (0.58%) of 6,001 PLWH experienced COVID-19 in Wuhan city, and 197 (3.3%) had discontinued ART despite tremendous supportive efforts from both governmental and non-governmental organizations (66). In Jiangsu Province, the HIV testing rates decreased by 49.0% (919,938) in the first three months of implementing COVID-19 measures (67). Of an estimated 1,555 new HIV diagnoses expected in the same period, only 63.0% new diagnoses were recorded (67). Links to HIV healthcare services including CD4 testing and ART were also seriously affected (67). Alternative or substitute ways to access healthcare for HIV during the COVID-19 epidemic might be considered. For example, Jiang et al. found that more MSM self-tested

for HIV (52.1% *vs.* 41.6%) but fewer MSM used facility-based HIV testing (42.9% *vs.* 54.1%) during COVID-19 measures compared to before COVID-19 measures (68). Furthermore, as compared to PLWH in other countries and the general population in most parts of the world, PLWH in China reported a relatively low willingness to receive the COVID-19 vaccination (69). The internet and social media as well as interpersonal communications may be major sources of influence on PLWH's perceptions and willingness to receive COVID-19 vaccination, which have important implications for immunization programs targeting PLWH.

SUMMARY

Despite aggressive and proactive national anti-HIV/AIDS strategies and action plans, the number of newly identified HIV infections, diagnostic delays, HIV risks among key populations such as MSM and their sexual partners continues to rise in China. Innovative HIV interventions such as PrEP and PEP as well as intervention delivery utilizing information technology are increasingly examined and motivated, but lessons learned are less than encouraging. Without a deeper understanding of macrosocial epidemiology of HIV, scaling up HIV testing and treatment will be a necessary but insufficient strategy to end the epidemic. Aged- and culturally-appropriate health education, coupled with social prevention strategies, need to be a high priority among China's national HIV prevention priorities. Meanwhile, current facility-based HIV services should also be complimented by community-led services and including key populations as central to their responses, which requires much more implementation research.

With HIV infection as a chronic disease and NCDs as leading causes of death, efforts on screening, prevention, and management of comorbid NCDs are now warranted. It is also necessary to re-focus some of the research agendas and/or priorities in China. Systems epidemiological research integrating multi-omics technologies could inform new biomarkers and biomedical targets for HIV prevention and treatment. Furthermore, PLWH are at increasingly and disproportionately higher risks of psychoactive stress and sleeping and mental health problems, so intervention programs to decrease perceived stress should be developed and implemented in China's resource-limited mental health settings. Moreover, as the COVID-19 pandemic continues to spread around the

world, it is particularly important to ensure PLWH have equal access to the utilization of health education, interventions, and services for COVID-19 as well as other diseases including HIV/AIDS.

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Recollections

HIV Prevention and Health Poverty Alleviation — Liangshan Prefecture, Sichuan Province, China, 2017–2020

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BACKGROUND

Liangshan, officially the Liangshan Yi Autonomous Prefecture, is an autonomous prefecture occupying much of the southern portion of Sichuan Province. It has been a remote and deeply impoverished area and also has the largest population of ethnic Yi people in China (1). For many years, due to geographical environment conditions, traffic conditions, and other historic restrictions, the human immunodeficiency virus (HIV) epidemic in Liangshan Prefecture has become the focus of HIV prevention and control in China since the first acquired immunodeficiency syndrome (AIDS) case was reported in this area in 1995 (2–3). Since then, newly reported cases of HIV/AIDS in Liangshan Prefecture have been rising in number every year, especially in 2006, 2007, and 2009, the newly reported number of HIV/AIDS cases increased exponentially over the previous years. In 2008, Butuo County of Liangshan Prefecture became the first county in China to report that living HIV-infected persons and AIDS patients accounted for over 1% of the resident population. In 2009, 2012, and 2013, Zhaojue, Yuexi, and Meigu counties, respectively, reported an HIV prevalence of over 1%. Efforts have been made at all levels to carry out HIV prevention and control, and some progress has been made. However, the local HIV epidemic has not been effectively controlled. In order to protect the people's health and promote poverty alleviation, the National Health Commission and Sichuan Provincial Government jointly issued the “First Phase Action Plan for HIV Prevention and Health Poverty Alleviation in Liangshan Prefecture, Sichuan Province, China (2017–2020)” (hereafter referred to as the “Action Plan”). Focusing on four key counties of Butuo, Zhaojue, Yuexi, and Meigu (hereafter referred to as the “four key counties”), a special campaign against HIV and poverty in Liangshan Prefecture was launched in September 2017.

After three years of effort, the initiatives implemented in this area have markedly improved the health of local residents, and contributed to local poverty alleviation. The purpose of this article is to summarize the key strategies and measures implemented, demonstrate the changes of core indicators of HIV prevention and control, and describe the contribution to local poverty alleviation, providing important reference for AIDS responses in other areas of China.

MAJOR STRATEGIES & MEASURES IN PRACTICE

Over the past three years since the implementation of the Action Plan, a series of strategies and measures have been implemented in Liangshan Prefecture. The local government and residences carried out all-round health education, conducted prevention of mother-to-child transmission (PMTCT), strengthened HIV screening, and implemented standard treatment of people living with HIV/AIDS. Moreover, they enforced drug control and rehabilitation, focused on HIV intervention among key populations, and aimed to mobilization of social forces to promote poverty alleviation through healthcare.

Health Education

The local government and its people have continuously searched for new and innovative ways to provide HIV/AIDS health education, mainly based on local sociocultural characteristics of the Yi ethnic group. It focused on promoting the formation of “active prevention” environments and advocated a healthy and civilized lifestyle. According to characteristics of different populations and ethnic minorities' customs, information, education, and communication (IEC) materials with bilingual and easy-to-understand language were developed to ensure full coverage of publicity and education. During the

“World AIDS Day”, “International Day Against Drug Abuse and Illicit Trafficking”, and the Yi Ethnic Festival, the local government made every effort to advance publicity and education on HIV prevention. It expanded the combination of regular and centralized health promotion to guarantee effectiveness, proposing that publicity on HIV prevention be combined with activities such as poverty alleviation, health literacy promotion, establishment of a “drug-free families” campaign, and rural activities for culture, science, and technology. In addition, professional publicity teams composed of those who understood local culture and knew the Yi language well were set up to carry out face-to-face education through home visits (4). Also, these teams used schools as the primary site for health education to comprehensively improve health literacy of the new generation. Sexual ethics, sexual responsibility, and safe sexual behaviors became the focus of education and were included in the training of HIV prevention in schools at all levels. In 2020, the public awareness rate of HIV-related knowledge was 95.84%, which increased by 61.22% compared with the baseline (34.62%) in 2017. Meanwhile, the awareness rate of HIV-related knowledge in 2020 among infected persons was 96.24%, an increase of 39.63% compared with the baseline (56.61%) in 2017. In addition, the number of high-risk groups that had multiple sexual partners and did not use condoms decreased. Patient medication compliance was also greatly increased.

Expansion of HIV Testing

In an attempt to maximally identify people living with HIV/AIDS, HIV testing was carried out among people with 18 months of age and above in free health check-ups for people in 8 counties severely affected by HIV in 2018, including the 4 key epidemic counties that had HIV prevalence over 1% among local residents and 4 other counties (Puge, Jinyang, Xide, and Ganluo). Meanwhile, provider-initiated HIV testing and counseling (PITC) was conducted among 100% of hospital inpatients, and 70% of outpatients in departments such as obstetrics and gynecology, dermatology, and urology of medical institutions at all levels in the 4 key counties. In addition, the informed and non-refusal HIV testing services among women of childbearing age was intensified, and free pre-marital healthcare, HIV testing for pregnant women in their first visit, and re-testing for pregnant women before childbirth were also implemented. Also, the grassroots HIV prevention teams in township health centers

guided village-level health workers to mobilize HIV testing. Village doctors provided a pregnancy testing service for HIV-infected women of childbearing age and helped mobilize and send them to medical institutions to receive healthcare services during pregnancy. All detainees in detention centers, such as drug maintenance treatment clinics, drug rehabilitation centers, and prisons, were tested for HIV on entry into the facilities.

Treatment

The four key county CDC and township health centers established a management system for tracking people living with HIV/AIDS. Once there were newly found untreated patients in the CDC or other medical institutions, they would be promptly referred to local antiretroviral treatment (ART) center for treatment. In this process, the strategy of “First diagnosis by medical institutions, seamless referral by CDC, timely treatment by designated medical institutions, and follow-up management by village health center” was put in place to avoid missing cases and ensure quality of treatment (5–6). Meanwhile, in order to achieve full coverage of HIV prevention and treatment services and precise management, the “1+M+N” triangle model was set up based on townships. “1” represented the responsible person in charge of township government who was also the first person in charge of HIV prevention and control in the town; “M” signified township responsible persons and health workers; and “N” was composed of village doctors, village health workers, and village maternal and child workers. In this model, several local innovative approaches were explored. The first one was called “Budi-ri”. As local people did not know what viruses and bacteria were, and they called the microorganisms that were harmful to their health “Budi-ri”. In the “1+M+N” model, village health workers showed a cartoon of “Budi-ri” and vividly demonstrated changes on the number of “Budi-ri” under standardized medication, non-standard medication, and no medication to the patients, which was of great help to the treatment work. The second was the practice of the “from mouth to stomach” strategy. In order to ensure correct and standardized medication and prevent treatment failure, village health workers delivered medicine to the patients’ homes, watched them take medicine, let them open their mouth after swallowing to ensure that the medication was consumed, and ensured the dosages were correct. The third one was called “color code

management”. According to the viral load testing results, cases of treatment failure were marked with “red”, and treatment success were marked with “blue”, which was convenient for classification management and helped to improve patients’ cognition of their own treatment.

Interventions Among Key Populations

Condom use was vigorously promoted by carrying out training on condom use, and free condoms were put in places where people would always see them in waiting areas of health institutions. Among HIV serodiscordant couples, local health staff conducted face-to-face health education and condom use guidance every quarter, mobilized them to receive ART, and further strengthened patients’ follow-up management. HIV testing for the negative spouse was conducted at least once a year and provided pre-exposure prophylaxis (PrEP) or post-exposure prophylaxis (PEP) services for those who were untreated or poorly treated. Meanwhile, it also strengthened comprehensive interventions on drug abuse, including standardization of methadone maintenance treatment (MMT) clinics management and improvement of compliance of drug users, maintaining treatment among drug addicts continuously. Extension points were set up in villages and towns in areas without maintenance treatment clinics, improving the accessibility of maintenance treatment. In addition, the connection between compulsory isolation and detoxification, community detoxification, community rehabilitation, and drug maintenance treatment was also further strengthened.

Prevention of Mother-to-Child Transmission

During the implementation of the “Action Plan” prevention of mother-to-child transmission was further strengthened. It included HIV testing during premarital examinations and the provision of health consultations, healthcare services, pregnancy and contraception guidance for infected women of childbearing age to help avoidance of unwanted pregnancy and timely referrals for treatment. With the guidance of family planning services, early detection of pregnant women, timely delivery of maternal and child healthcare services, and HIV testing were conducted. Pregnant women with HIV infection were included in the high-risk population management, and were urged to receive regular pregnancy and childbirth healthcare, relevant auxiliary examinations, and hospital delivery.

Free hospital delivery services were provided for infected pregnant women, and standardized prevention and intervention services were provided for them and their newborns (7–8). Those waiting to give birth and pregnant women living in remote areas were encouraged to be hospitalized for delivery in advance. Additionally, it advocated “one-to-one” tracking of infants born to pregnant women, guiding them to take preventive ART drugs, feeding, and early diagnosis of HIV.

MAIN OUTCOMES

Basic Changes

In 2019, there were 4,694 and 1,964 newly reported HIV-infected persons and AIDS patients in Liangshan Prefecture and the four key counties, decreasing 15.73% and 37.33% compared with that in 2017, respectively, and had an average annual reduction rate of 8.90% and 26.32%, respectively. The proportion of newly reported cases of 4 key counties in the whole prefecture decreased from 56.27% in 2017 to 41.84%. By the end of 2019, there were 24,663 survivals of HIV/AIDS in the 4 key counties, accounting for 59.40% of the whole prefecture, with a decrease of 5.11% compared with that in 2017. As of 2019, the number of people involved in HIV prevention and control was 3.67 times that of 2017. The number of HIV-infected persons per capita of health workers was reduced from 21.98 in 2017 to 6.52 in 2019. From 2017 to 2019, AIDS funds from the central government, Sichuan Province, and Liangshan Prefecture increased year by year. The continuous investment of funds has comprehensively promoted the construction of medical and health service systems and the cultivation of health personnel teams at the prefecture, county, township, and village levels. It has also advanced the information construction and whole-process traceability of drug management and supplemented the shortcomings of infrastructure and medical equipment of grass-roots medical and health institutions. The basic changes including the number of infected persons, AIDS funds, and number of health staff engaged in the AIDS response were shown in detail in Table 1.

Changes of Core Indicators

By the end of 2020, the proportion of people living with HIV who knew their HIV status, the proportion of people with diagnosed HIV infection who received

TABLE 1. Basic changes in Liangshan Prefecture and 4 key counties from 2017 to 2019.

Indicator	Liangshan Prefecture				Four key counties			
	2017	2018	2019	2020	2017	2018	2019	2020
Basic information								
Number of living infected persons	34,964	38,545	41,524	43,697	22,553	24,224	24,663	25,534
Number of newly reported infected persons	5,570	10,105	4,694	3,018	3,134	6,714	1,964	1,456
AIDS funds								
Central government investment (100 million yuan)	0.45	0.87	1.3	1.9	0.21	0.43	0.59	–
Financial investment of Sichuan Province (100 million yuan)	0.14	0.72	0.77	0.08	0.02	0.31	0.28	–
Financial investment of Liangshan Prefecture (100 million yuan)	0.19	0.21	0.22	0.22	0.05	0.02	0.02	–
Staff on AIDS response								
Number of people responsible for local management (persons)	404	504	575	–	105	188	195	–
Number of people engaged in “1+M+N” system	9,282	12,217	11,143	–	1,026	4,072	3,781	–
Per capita number of infected persons managed by “1+M+N” system	3.77	3.16	3.73	–	21.98	5.95	6.52	–

Note: –: Data not available.

Abbreviation: AIDS=acquired immunodeficiency syndrome.

sustained ART, and the proportion of people receiving ART who had viral suppression reached 90.52%, 94.81%, and 94.80%, respectively, which was an increase of 10.80%, 130.68%, and 64.87%, respectively; the mother-to-child HIV transmission rate, sero-discordant couples transmission rate, and HIV new infection rate decreased to 3.66%, 0.85%, and 0.02%, respectively, which was a decrease of 59.33%, 87.94%, and 68.75%, respectively. In the past three years, the HIV detection rate, ART coverage, and HIV viral suppression rate rose steadily; meanwhile, MTCT rate, transmission rate among sero-discordant couples, and HIV new infection rate

decreased significantly. See Figure 1 and Table 2 for details.

CHALLENGES & PROSPECTS

During the three-year period, positive changes of the main indicators on HIV prevention and control were seen in Liangshan Prefecture. The mechanism of HIV prevention and treatment has been improved, and primary medical services have been elevated; in addition, major breakthroughs have been made in important and difficult tasks such as treatment, PMTCT, and HIV prevention among key populations

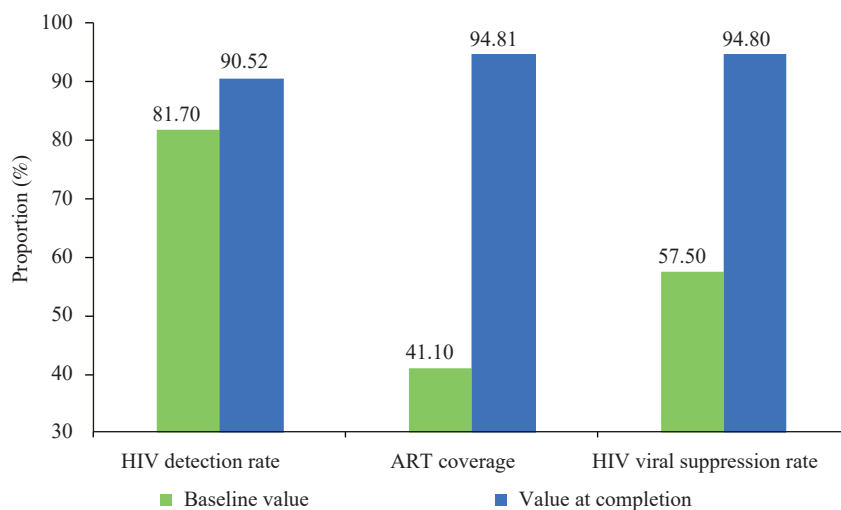


FIGURE 1. Changes of HIV detection rate, ART coverage, and HIV viral suppression rate between baseline and completion. Abbreviations: HIV=human immunodeficiency virus; ART=antiretroviral treatment.

TABLE 2. Changes of MTCT rate, HIV transmission rate among sero-discordant couples, and HIV new infection rate from 2017 to 2020, Liangshan Prefecture.

Indicators	Baseline value	Value at completion
MTCT rate (%)	9.00	3.66
HIV transmission rate among sero-discordant couples (%)	7.05	0.85
HIV new infection rate (‰)	0.64	0.20

Abbreviations: MTCT=mother-to-child transmission; HIV=human immunodeficiency virus.

(9). In fact, Liangshan Prefecture's practice on HIV precision management and primary medical and health services provision not only ensured the effectiveness of local HIV prevention and treatment, but also provided an important reference for the prevention and control of major chronic infectious diseases at the grass-roots level in other similar areas in China.

At present, Liangshan Prefecture still encounters significant challenges in HIV prevention and control. For instance, although technical personnel have been trained in recent years, the local capacity of HIV prevention and control at the township and village levels needs to be further improved. And also, the assessment and evaluation system at the local level still needs to be refined. The evaluation methods for the workload and effectiveness of "1," "M," and "N" still need to be adjusted and improved to better standardize and quantify their workload, so as to improve the evaluation systems for both the township and village levels (10). In addition, the sustainability of the current response needs to be considered and laid out. Strong government leadership, participation of the whole society, and financial support were the "engine" of the sustainable development of AIDS response; however, due to different situations of villages and towns and different factors affecting work sustainability, the current response needs to be gradually adapted in line with the needs of different scenarios of areas, so as to maintain its overall sustainability.

In summary, Liangshan Prefecture's efforts have been seen as China's best practice on the consolidation of "four-party responsibilities" of the government, departments, society, and individuals. Looking to the years ahead, efforts should be continuously made to further boost the achievements for further strengthening AIDS response and controlling the HIV epidemic effectively. Also, the instructive exploration on the grassroots AIDS response in this area is worth learning, popularizing, and applying in other severely affected HIV-epidemic areas in China.

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